Comparison in physicochemical attributes changes between soy pretzels made with various saturated lipids at 10% or 40% oil concentration

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Abstract

Pretzels, traditionally made with 3-6% shortening, is popular snack in America resulting in over 500 million in sales in 2010. Thus incorporating ingredients shown to decrease biomarkers of obesity in this popular snack food may provide an excellent means of enhancing nutrition. In previous studies, high safflower-oil diets induced fat-mass reduction by influencing lipogenesis and lipid metabolism gene expression; while thermogenesis, rate body generates heat, was affected differently due to different saturated level fatty-acids consumed. Soy protein was observed to inhibit insulin resistance regardless of high fat diet, commonly associated with potential diabetic concerns. The objective was to select a type and amount of lipid that will least affect the texture and water distribution of a optimized soy pretzel. Changes in amount, composition (chain-length, degree of saturation) and crystalline polymorph of added lipid affect the pretzels physicochemically and may lead to undesirable food products. Therefore, we hypothesized that higher concentration and degree of saturation of lipids will significantly decrease the physical structure of soy pretzels, and change their water distribution. Soy pretzels were formulated with 4 types of lipids: Ghee(G), shortening(S), coconut-oil(CO), and high oleic safflower-oil(SO) at concentrations of 10% and 40%. Instrumental analysis was conducted in triplicate for “freezable” water and textural attributes (hardness, springiness and chewiness). Significant decrease in all 3 textural attributes were observed between10% and 40% with CO, G and S least to most respectively, but not SO. Lipid composition had no significant functional difference at 10%, but at 40% functional difference divided them to 3 groups (CO; G and S; SO). As hypothesized, safflower oil, rich in mono-unsaturated triglycerides, changed the least in texture properties compared to saturated fats, and showed a reduction of percent “freezable” water in soy pretzel. Thus a safflower oil/soy pretzel will be utilized in future human clinical trials.

Introduction and Justification

Pretzels, traditionally made with 3-6% shortening, is a popular snack in America resulting in over 500 million in sales in 2010. Incorporating ingredients shown to decrease biomarkers of obesity in this popular snack food may provide an excellent means of enhancing nutrition (Noriega-López abd and others 2007). In previous studies, diets rich in safflower oil induced fat-mass reduction by influencing lipogenesis and lipid metabolism; while thermogenesis was mediated by saturation of fatty-acids(Huc and Huang 2006). Various studies indicated soy protein have anti-obesity implications. Changes in amount, composition (chain-length, degree of saturation) and crystalline polymorph of added lipid affect the pretzels physicochemically and may lead to undesirable food products.

Added lipids are crucial for bread making, so understanding how much difference there could be brought by the different varieties in types and amount of lipids is beneficial for bakery industry such as bread and pretzels. Previous researches by the Ohio State University pointed out that tenderer crumb developed with the increase of oil content, however ground almond paste adversely affected it(Simmons and others, 2014). Furthermore, the liquid oils did not attach to the surface of gas cells as well as the solid fat, so solid fat give more homogeneous crumb than liquid oil(Simmons and others, 2014). Their experiments were conducted with 0%, 2.9% or 6% lipids. In this research the scale will be raised. Instead of using the typical amount of lipid, average around 3-4% in bread making, the lipid amount added will be 10%,20%, 30%, 40% of the dry basis.

Base on the structures of the hydrocarbon chain, there are divisions in fatty acids. Saturated fatty acyls, which contain no double bond, and unsaturated fatty acyls, which contain one or more double bonds, are the most common forms in nature (Smith and Johansson, 2004). Most of animals fats are even numbered carbon hydrogen saturated fatty acid chains,which most commonly formed as the stearic acid or palmitic acid, so is the hydrogenated vegetable oil. Unsaturated fatty acid with one double bond is the monounsaturated fatty acid(MUFA),and the most common form in nature is oleic acid($18{:}1\Delta^{9}$) with cis configuration (Smith and Johansson, 2004). Unsaturated fatty acids with more than one double bond are called the polyunsaturated fatty acyls(PUFA)(Smith and Johansson, 2004). Most of the double bonds are three carbons apart including the ones we are using in this research α-linolenic acid($18{:}3\Delta^{9,12,15}$), which is also referred as the omega-3 fatty acid, and linoleic acid($18{:}2\Delta^{9,12}$), which is referred as the omega-6 fatty acid(Smith and Johansson, 2004). However, dietary lipids do not simply exist in the simple fatty acyl forms. Instead, they compose esterified fatty acyls and mostly exist in form of triacylglycerols(TAG). There are three polymorphic arrangements of the TAG, α-, β- ,β'-(Smith and Johansson, 2004).

This research was unique and significant because there is no other research has investigated such high level dosage of lipid in a bread matrix and the varieties of the lipids. The objective was to select a type and amount of lipid that will least affect the texture and water distribution of an optimized soy pretzel.

Variable Selection

The lipids investigated are coconut oil, ghee, shortening and high oleic safflower oil. Base on the structures of the hydrocarbon chain, there are divisions in fatty acids(see Table 1.). Lipids can also be classified by their crystalline behavior, including *alpha-, beta-,* and *beta-prime* forms. Ghee and shortening are classified to *beta-prime* type, while safflower and coconut are *beta* type. *Beta-prime* polymorph is usually the most stable and functional in fat products.

Table 1. Fatty acid composition of Coconut oil, Ghee, Shortening and Safflower

Oil	Saturated fat	Mono-unsaturated fat	Poly-unsaturated fat
Coconut Oil	91% (50% lauric acid C12)	6%	3%
Ghee	68%	28%	4%
Shortening	52% (35% palmitic acid C16)	22%	26%
Safflower Oleic Oil	7%	76%	12%

Method

The soy pretzels in this research are made with 202 grams soy mix(soy milk: soy flour;1:3), 33% water for all formulas with the oil content varied from 10%, 20%, 30%, 40%, and total ingredient mass of one kilogram. The only variables are wheat flour to compensate the oil content increase. Each formula will have triple replicate. The base dough is made with all of the wheat flour, wheat gluten(9.2g), sugar(8.4g), salt(6.8g), half of the yeast(3.6g) and about 80% of water in the formula. Only the base dough with the same oil content will be prepared at the same time. The dough will ferment for about 1.5 hours individually. Then soy mix, oil, dough conditioner(1.2g) and rest of water are added to the fermented dough, mixed with paddle attachment. The dough is knitted to pretzel about 100g each and 3*3*7cm. Then the pretzel dough is proofed for 10 minute and bake at 325 degree for 15 minutes.

The instruments used to test are thermogravimetric (TGA), differential scanning calorimetry(DSC) and Instron Universal Texture Analyzer. For DSC and TGA, double replicate will be taken for each batch. All the first replicates will be taken the day after the baked day, and triple duplicate will be taken for the instron on the same day. The storage condition for the first replicate is room temperature storage in plastic bag after 20 minutes cooling. After the first replicates data are collected, the pretzels will be stored in the freezer and the second replicate for DSC and TGA data will be collected within a week after baking. Rapeseed displacement will be conducted to measure the volume of the pretzels. See Figure 1 for method in diagram.

Overall, soy pretzels were made by mixing, proofing, alkaline spraying**,** baking, and then were frozen until instrumental analysis. Samples varied in types (coconut oil, ghee, shortening and safflower oil) and amount (10% and 40%) of lipids were analyzed to give total water content, amount of bounded water and textural attributes (hardness, springiness and chewiness) results.

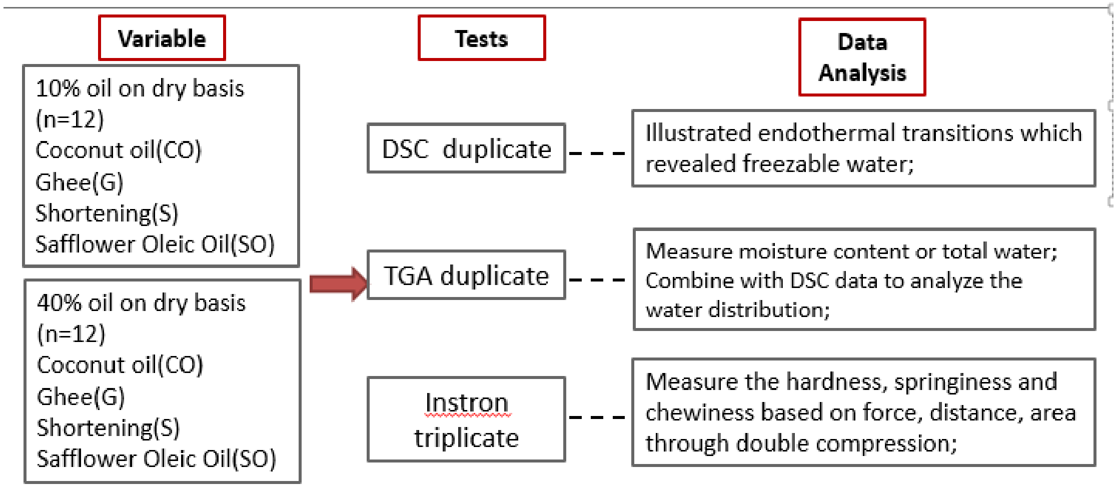

Figure 1. Experiment set up and instrument application

Result

At 10% lipid level, there was no a significant difference in any attribute analyzed between the 4 lipids(fig. 2). At 40% lipid level, the percentage of unbound water decreased with shortening and safflower oil. Safflower oil maintained textural attributes at both lipid level, but ghee and shortening modulated pretzels similarly to be softer, less springy, and less chewy at 40%. In conclusion, significant differences in texture were observed between 40% and 10% with coconut oil, ghee and shortening least to most respectively, but not safflower oil(Fig 3 and Fig 4). Degree of saturation had no significant functional difference among lipids at 10%, but at 40% in soy pretzels. As hypothesized, safflower oil was the one impacted the least, in fact insignificantly, in texture properties, but also positively reduced the unbounded water percentage in soy pretzel.

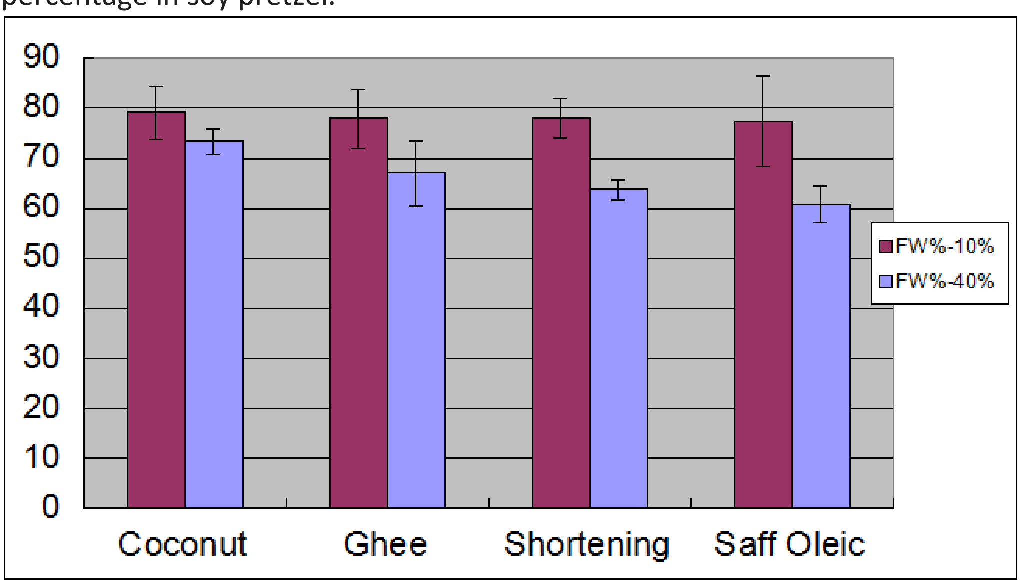

Figure 2. Percentage of Free Water to all water in the soy pretzels made with coconut, shortening, ghee and safflower oleic oils at 10% and 40% in the dry basis

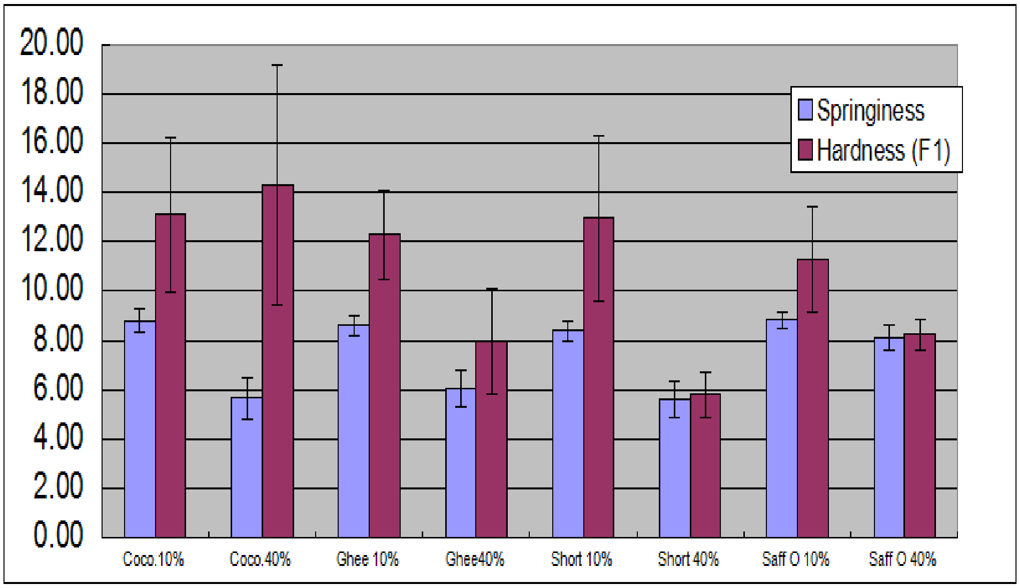

Figure 3. Springiness(mm) and Hardness(N) the soy preztels made with coconut, shortening, ghee and safflower oleic oils at 10% and 40% in the dry basis

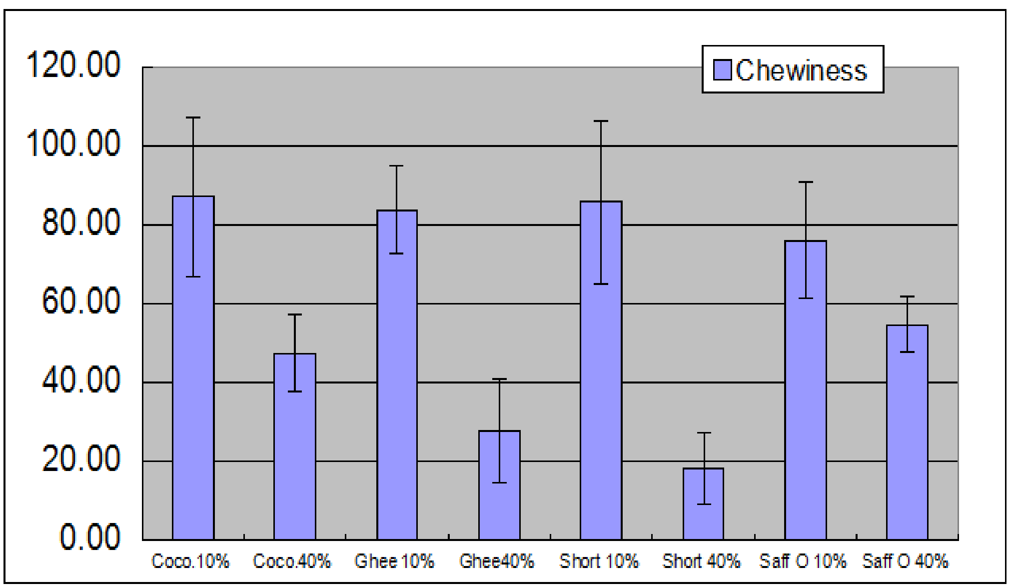

Figure 4. Chewiness(**N**) the soy pretzels made with coconut, shortening, ghee and safflower oleic oils at 10% and 40% in the dry basis

The free water content decreases with the increase of oil content for four types of lipid (Fig 2). At 10% lipid level, the springiness, hardness, chewiness and free water percent of soy pretzels made from these four lipids do not have significant difference. At 40% lipid level, the springiness of pretzels with C, G and S were not significantly different to each other but decrease compared to 10%; while the springiness of SO is indifferent to 10%, thus significantly higher than other lipids. For hardness, 40% lipid level correlates to decrease in hardness of S (most), G and SO soy pretzels; while hardness from CO is not significantly different to 10%, thus highest of the four. Chewiness decreased with the lipid content increase; shortening, ghee, coconut and safflower oleic had the lowest chewiness to the highest respectively. Free water content decreases significantly for SO and S while indifferent for CO and G at 40% (Fig 3 and fig 4).

The free water content decreases from relevant equivalent amount at 10% lipid level with the increase of oil content S and SO. Significant decrease in all 3 textural attributes were observed between10% and 40% with coconut-oil had the lowest values, followed by ghee and shortening having the most whereas safflower oil concentration did not affect texture. The effects of lipid composition was observed at 40% where significant difference segregated into 3 groups (CO, SO, and G and S), but not at 10% oil concentration.

Conclusion

Safflower oil, rich in mono-unsaturated triglycerides, changed the least in texture properties compared to saturated fats, and showed a reduction of percent “freezable” water in soy pretzel. Thus a safflower oil/soy pretzel will be utilized in future human clinical trials.

Future direction

Sensory testing can be used affirm the acceptability for soy pretzels with safflower oleic oil at high percentage. Measures by colorimeter, loaf volume, rheological studies and X-ray diffraction on starch gelation can be applied to compare among the soy pretzels with these oils. Additionally, since the oil concentration is high, lipid oxidation is a potential concern. Monitoring lipid oxidation is helpful information for further development if these are to be commercial products.